

ELECTRONIC FUNDAMENTALS

Service Practices 15:

HOW TO TEST CAPACITORS

Service Practices 16:

HOW TO USE CATALOGS
AND SERVICE DATA



RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

New York.

N. Y.

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 15

HOW TO TEST CAPACITORS

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15-2. Capacitor Defects

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RCA INSTITUTES, INC.

**A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL**

350 West 4th Street, New York 14, N. Y.

Service Practices 15

INTRODUCTION

Radio and television receivers use many capacitors, and they are found in a variety of different forms. Most of the capacitors used are *fixed* capacitors. These have dielectrics made of paper, mica, or ceramic material. Another type of fixed capacitor (the capacitance value of such capacitors is greater than about 1 μf) is the *electrolytic* type. The dielectric of an electrolytic capacitor is an aluminum-oxide film formed by chemical action, as explained in earlier lessons. Another type of capacitor, which is found in most radio and television receivers, is the *variable* type. The capacitance of variable capacitors can be changed for tuning purposes. The dielectric of variable capacitors is usually air; some variable capacitors use mica as a dielectric.

When capacitors become defective, they cause a radio receiver to either stop operating, become noisy, develop hum, or operate in some other unsatisfactory manner. In this lesson you will study how to test capacitors and how to replace defective ones.

Fixed paper-, mica- or ceramic-dielectric capacitors are all tested in the same way. Slightly different methods are used to test electrolytic capacitors, and still other tests are used for variable capacitors. We will first discuss the testing of non-electrolytic fixed capacitors, and then describe additional techniques needed for the other capacitors.

15-1. TYPES OF FIXED CAPACITORS

Capacitors are usually classified accord-

ing to the dielectric material that they use. Some sections of radio or television receivers require ceramic-dielectric capacitors, called ceramic capacitors. Mica capacitors may be used in other sections of the receiver, and paper capacitors may be used in still other sections. (Electrolytic capacitors will be discussed in later sections of this booklet).

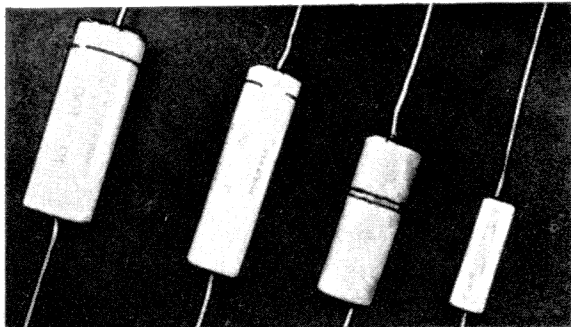
It is important to be able to recognize the various capacitor types. Fortunately, each type of capacitor has its own characteristic size and shape. You will soon learn how to tell the type of capacitor at a glance.

Paper Capacitors. Usually paper capacitors are tubular in shape. A number of typical paper capacitors are shown in Fig. 15-1. The outside case of such capacitors may be either a cardboard tube that is covered with wax to keep out moisture as shown in Fig. 15-1a, or a molded plastic case as shown in Fig. 15-1b. Paper capacitors may sometimes be found in a flat molded case, as shown in Fig. 15-1c. Paper capacitors are almost always used at audio frequencies, and in parts of the circuit where extremely high insulation resistance is not required.

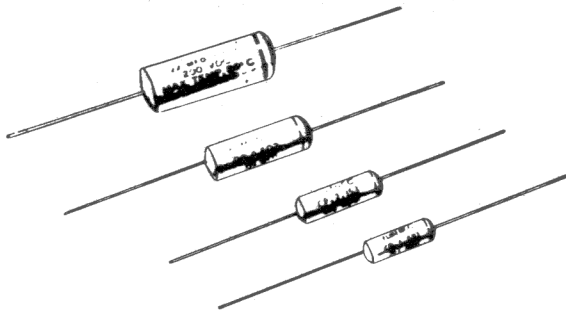
Mica capacitors usually are enclosed in a flat rectangular case, as shown in Fig. 15-2, and color-coded with 6 dots, as described in the lesson on color codes. Their appearance has caused many servicemen to call them "postage-stamp" capacitors. Mica capacitors usually are used at r-f and i-f frequencies.

Ceramic Capacitors. Ceramic capacitors are produced in the various shapes and sizes shown in Fig. 15-3. Many special types of ceramic capacitors are available, such as temperature-compensating capacitors and high-voltage capacitors. Combinations of two or more capacitors in one unit are also available.

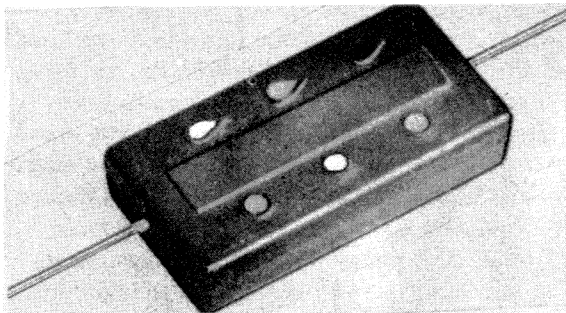
In this unit, the center lead is common to both capacitors. Ceramic capacitors are usually used at r-f and i-f frequencies.



(a)



(b)



(c)

Fig. 15-1

15-2. CAPACITOR DEFECTS

All types of capacitors may have any one of the following defects:

1. Shorted
2. Leakage
3. Open
4. Changed capacitance value

A *shorted* capacitor is one in which the dielectric material between the plates has

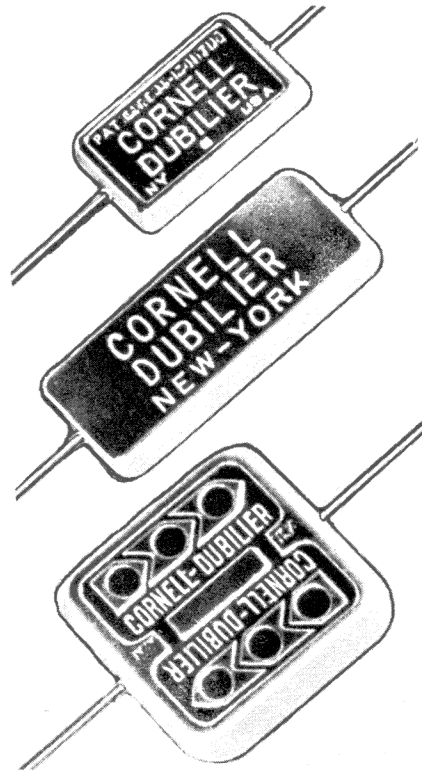


Fig. 15-2

broken down and a direct conducting path exists between the capacitor plates, as shown in Fig. 15-4a. What usually happens is that the insulation fails at some point, allowing current to flow. The heat begins to char or burn the insulation at that point. The burned insulation allows more current to flow, and this cycle repeats itself until, eventually, the insulation is completely burned through and a conducting path is formed between the plates.

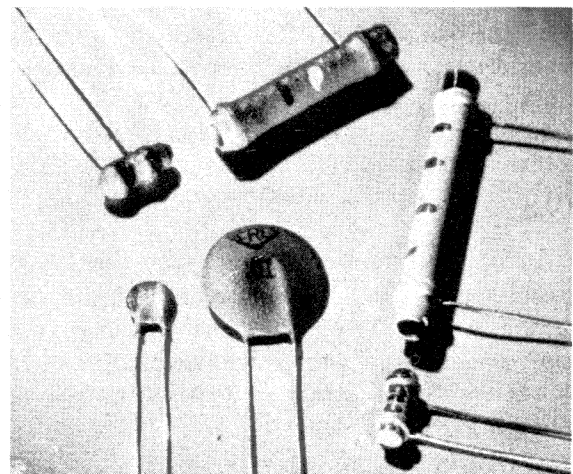


Fig. 15-3

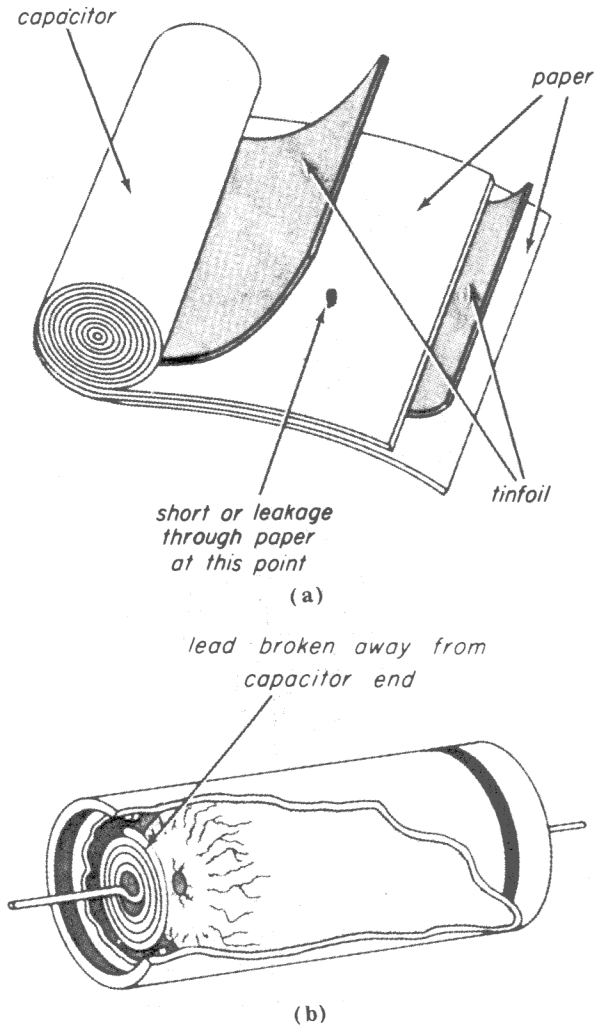


Fig. 15-4

A *leaky* capacitor is one in which there is a partial conducting path between the capacitor plates. The leakage may be through or around the dielectric. This is usually caused by moisture inside the capacitor case. Such a capacitor acts as if it were shunted by a resistor. The greater the leakage, the smaller is the effective shunting resistor. All capacitors have some leakage, since some current flows through even the best insulating material. However, the insulation or leakage resistance of good capacitors is usually 1,000 megohms or higher.

An *open* capacitor is one with the leads disconnected from the capacitor plates, as shown in Fig. 15-4b. This may be due to a poor connection during manufacture, rough or excessive handling, or excessive current through the capacitor.

All of these defects may be intermittent

and may come and go so erratically (that is, with no regular pattern) that they are difficult for the service technician to find. We will discuss ways of finding such intermittent defects later on.

A capacitor may sometimes change value, or may have the wrong value from the start. This may be due either to wrong marking or to defects in manufacture. Such defects are rather rare. However, you should know how to measure the capacitance of a capacitor. You will learn how this can be done later.

15-3. TESTING FIXED CAPACITORS

The following are five general methods for testing fixed capacitors:

1. Inspection method
2. Using the ohmmeter
3. Using the d-c voltmeter
4. Capacitor substitution method
5. Using the capacity bridge

As these tests are described, refer to the circuit of Fig. 15-5. This circuit is the audio-amplifier portion of a radio receiver. Capacitor C is the *coupling capacitor* between V_1 and V_2 . A typical size for this purpose is

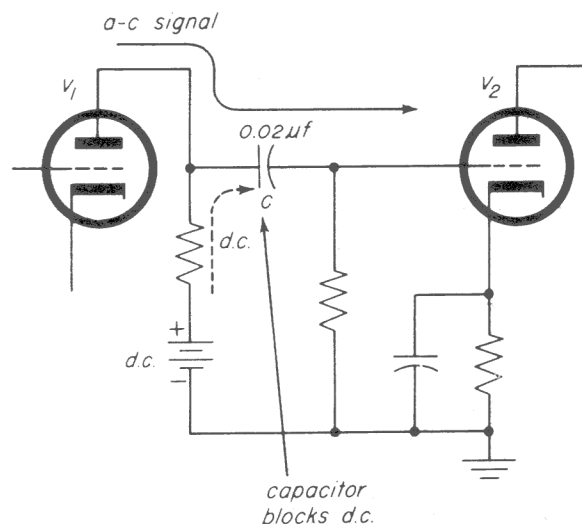


Fig. 15-5

0.02 μf . As you have learned, capacitors pass a-c signals but block d-c voltages. That is the purpose of capacitor C in this circuit. It passes or *couples* the a-c signal from V_1 and V_2 , but blocks the d-c voltage at the plate of V_1 from the grid of V_2 . Here are some of the faults that would be noticed if capacitor C were defective:

1. If C were shorted, the set would not operate.
2. If C were leaky, the sound output of the receiver would be very distorted, and might be very low in volume.
3. If C were open, the receiver would not operate.
4. If C were the wrong value, the receiver would not operate properly.

Inspection Test. An inspection test sometimes, but not always, points out a defective tubular paper capacitor. Molded paper or mica capacitors usually show no outward sign of being defective. Examine the capacitor to make sure that the end leads are not loose and are firmly encased in the wax, which is used to help keep out moisture at both ends of the capacitor. Gently pull on each end lead of the capacitor to see that they are tight and do not pull out. Next, plug in the power cord and turn on the receiver. Tune in a station if the set is operating. Push against each of the two capacitor leads and the body of the capacitor with an insulated tool to see if the capacitor has an intermittent loose lead inside the case. Make sure that the leads do not touch other bare wires or other parts. If an intermittent condition is present, the set will stop and then start to operate each time the capacitor lead is prodded with the insulated tool.

Another way to inspect the capacitor is to feel it after the set has been operating for a while. Sometimes a leaky or shorted capacitor will feel warm or even hot to the touch. However, all of the parts in a radio receiver may become warm after the set has been turned on for a while. So, use good judgement when using the sense of touch; do not replace a paper tubular capacitor unless it is very much warmer than the other

parts close to it. Sometimes the wax melts and drips down from the ends of the capacitor. This is not always due to a defective capacitor but instead is due to the normal heating of the set. However, a capacitor from which all the wax has melted out is liable to become defective and should be replaced.

Ohmmeter Test. Testing with an ohmmeter will indicate if the capacitor is either shorted or leaky. An ohmmeter also can be used to test some capacitors to see if they are open.

Here is how we use the ohmmeter to test capacitor C to determine if it is shorted or leaky. First, remove the power plug from the socket. (If the set is a portable, disconnect the batteries and remove the tubes from their sockets.) Disconnect one of the leads of capacitor C from the radio receiver circuit, allowing it to hang free.

Caution: When soldering leads, be sure not to burn nearby insulation or parts with the hot soldering iron. Also prevent melted solder from falling into the chassis or onto parts.

Set the ohmmeter selector knob to the highest, or $R \times 10K$ position. Place the ohmmeter test probes on the leads of capacitor C , as shown in Fig. 15-6. The leakage resistance of a good paper capacitor is 1,000 megohms or more. This cannot be measured

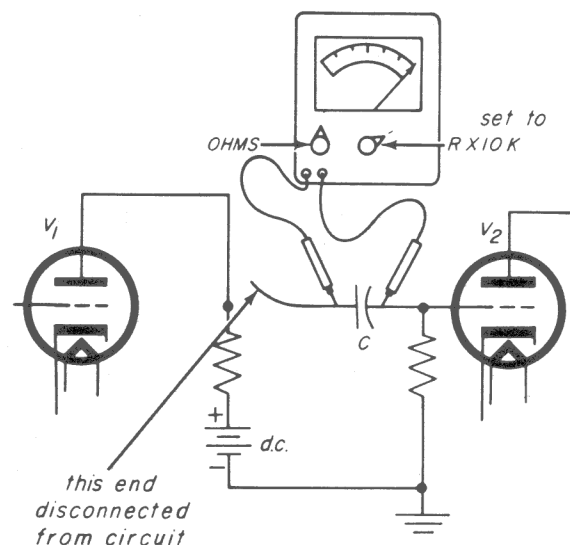


Fig. 15-6

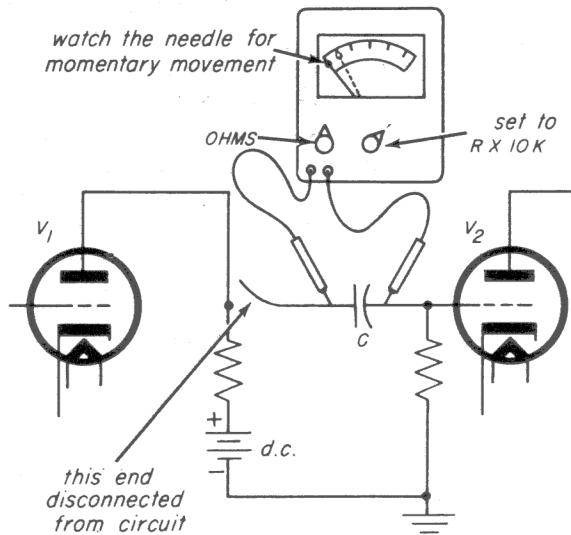


Fig. 15-7

on the average service-type ohmmeter. Therefore, if the ohmmeter gives any reading other than infinity, the capacitor is defective and should be replaced. Be careful not to let your fingers touch the ohmmeter test prods or the capacitor leads when making leakage tests, because this will cause the ohmmeter to give a resistance reading.

Some capacitors can be tested with an ohmmeter to see if they are open. This test is reliable only for capacitors that are $0.01 \mu\text{f}$ and larger; with capacitors of smaller values, it becomes difficult to see the deflection of the ohmmeter needle. In order to test capacitor C for an open condition, proceed as follows:

1. Turn the ohmmeter selector knob to the $R \times 10 K$ position.
2. Disconnect one of the capacitor leads, as shown in Fig. 15-7. Discharge the capacitor by shorting the leads together. Connect the unsoldered lead to one of the ohmmeter probes.

3. Touch the other probe to the other capacitor lead and at the same time observe the ohmmeter indicating needle. If the capacitor is open, the indicating needle will not move at all but will remain in a stationary position at the end of the scale. The capacitor should be discharged if the same test is to be tried again.

If the capacitor is not open, the needle will

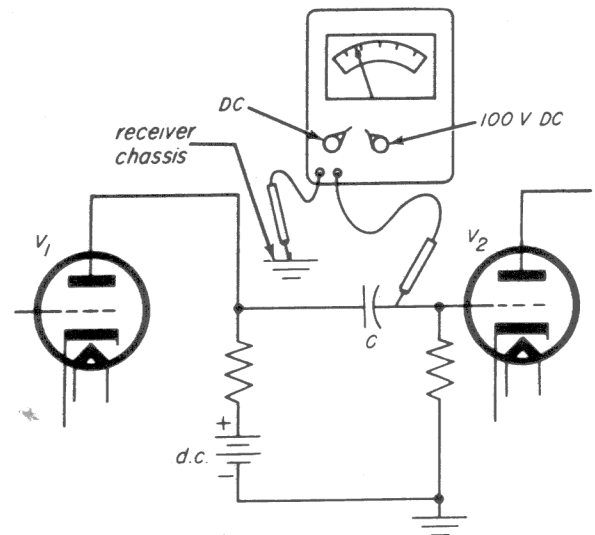


Fig. 15-8

quickly move from its position at the extreme left of the scale to some point on the ohmmeter scale and then more slowly return to its extreme left-hand position. This needle movement from left to right and then back again shows that the capacitor is not open and is taking a charge from the dry cells in the ohmmeter. The larger the capacitance value of the condenser, the farther to the right the needle will go, showing that a greater charge is being taken. Small values of capacitance will barely move the needle, due to the small charge which they take.

Voltmeter Test. A d-c voltmeter is often used to test a capacitor that may be either shorted or leaky. It also may be used to see whether the capacitor is open. To test a capacitor to see if it is shorted or leaky, proceed as follows:

1. Reconnect the capacitor as it would normally be in the circuit, as shown in Fig. 15-8.
2. Install all tubes, insert the line plug into the outlet, and turn the set on.
3. Turn the voltmeter selector knob first to the 500 VDC position.
4. Connect the positive probe of the d-c voltmeter to the grid of V_2 and the negative probe to the chassis of the receiver.

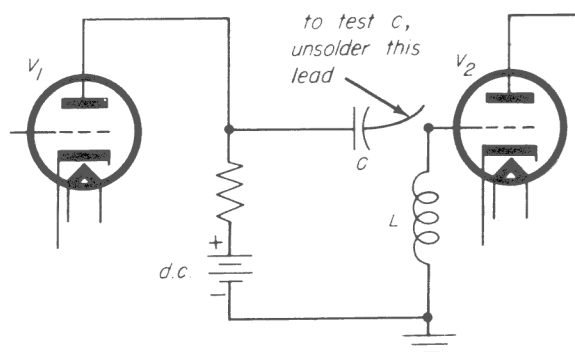


Fig. 15-9

5. Turn the selector knob to the 100 VDC, 25 VDC, and 5 VDC positions. If you get a positive voltage reading, the capacitor is either shorted or leaky.

A large voltage reading means a *shorted* capacitor while a *smaller* voltage means a *leaky* capacitor. For example, if the voltage on both sides of the capacitor is 130 volts, capacitor C is shorted. If the voltage reading is 130 volts on one side and only 4 volts on the other, C is leaky. If C is found to be either leaky or shorted, it should be replaced with a new capacitor.

In a circuit like the one shown in Fig. 15-9, inductor L is a very low resistance coil. In this case, even if C were shorted, no positive voltage could be measured at the grid of the tube because of the low resistance of L . In order to check whether C is shorted in this circuit, it is necessary to unsolder the capacitor from the grid side of the circuit. Then, with the power on, one lead of the voltmeter should be touched to the free capacitor lead while the other side of the voltmeter is held at ground. Voltage will be indicated on the meter if there is any leakage through the capacitor.

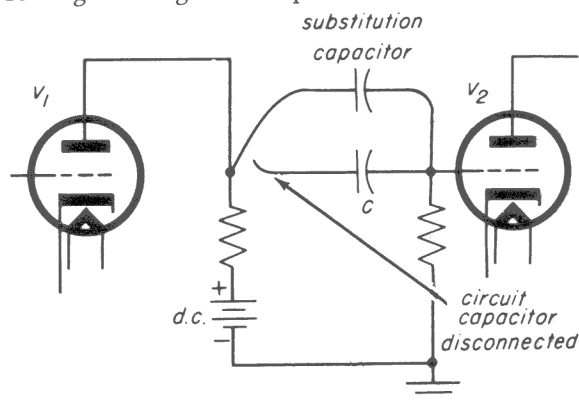


Fig. 15-10

If a source of d-c voltage is available, as in a receiver, capacitors can be checked for open circuits using a d-c voltmeter. This is done as follows:

1. Disconnect the grid side of the capacitor. Leave the side that goes to B+ connected. (If the capacitor is in a circuit where there is no B+ voltage on either side, connect one side temporarily to a B+ point.) Set the meter up to read d-c volts on the 500-volt scale.

2. With one side of the voltmeter connected to ground, touch the other test prod of the voltmeter to the free side of the capacitor. If the capacitor is not open, the voltmeter needle will immediately deflect to the right and quickly return.

3. If no deflection is obtained, discharge the capacitor, set the voltmeter to a lower range, and try again. If no deflection is obtained on the lowest scale, the capacitor is open.

Substitution Method. In the substitution method, a capacitor having the same capacitance value and voltage rating is used in place of the capacitor being tested. For example, to determine if capacitor C in Fig. 15-10 is defective if the set sounds choked up and distorted, proceed as follows:

1. Disconnect capacitor C from the circuit by unsoldering one of the leads.

2. Connect both leads of a new $0.02\text{-}\mu\text{f}$ capacitor having a 400-volt rating in place of capacitor C , as shown in the figure.

3. Turn on the set and tune in a station. If the set operates normally with good tone quality, capacitor C is defective and should be replaced with a new capacitor.

Figure 15-11 shows how a capacitor may be kept on hand, ready for the substitution-

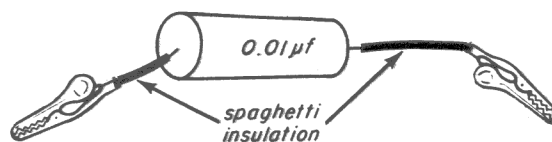


Fig. 15-11

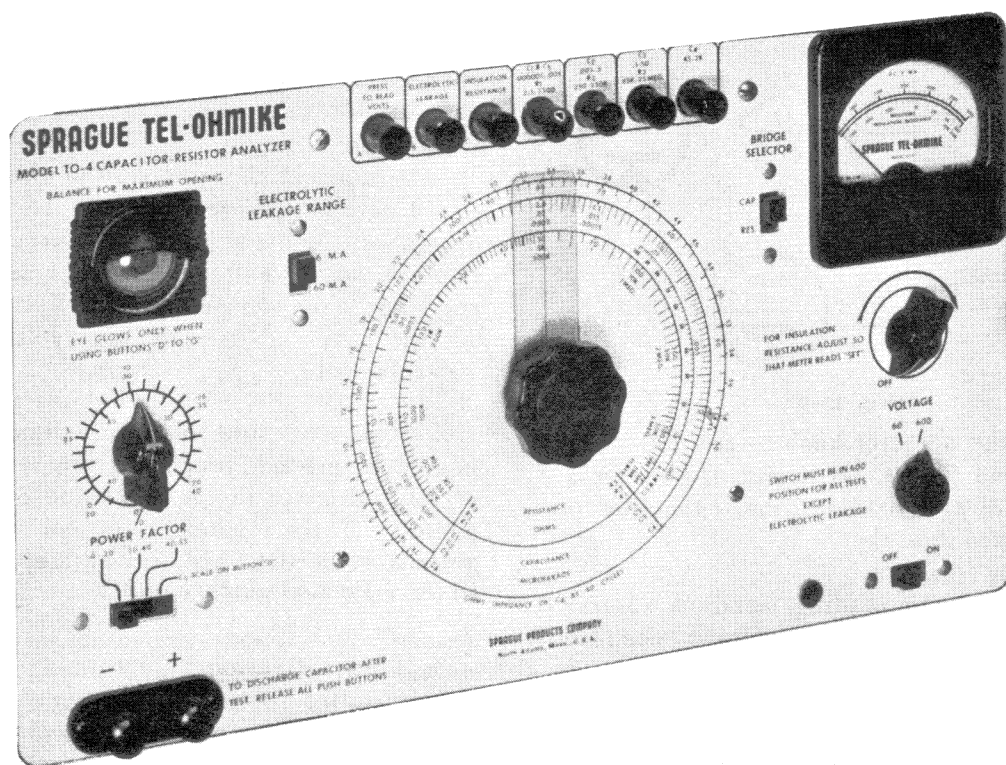


Fig. 15-12

testing method. Five capacitors ranging in values from $0.00001 \mu\text{f}$ to $0.1 \mu\text{f}$ having voltage ratings of 400 volts with alligator connector clips permanently fastened to the capacitor lead will be enough to take along on service calls. Whenever the substitution method is to be used, the old capacitor is disconnected and one of the five capacitors (the one with the closest value) is clipped into place. If desired, other capacitance values can be chosen and more than five capacitors with clips can be made up, which gives a larger variety to choose from. Some servicemen mount capacitors on a board and connect them to a selector switch so that different capacitors can be quickly selected.

Using A Capacitor Analyzer. The most complete testing of a capacitor can be done with a capacitor analyzer. A typical commercial capacitor analyzer is shown in Fig. 15-12. An analyzer of this type can be used to check for shorts, leakage, or open circuit, measure the capacity value and power factor of a capacitor, and measure the amount of leakage resistance in megohms.

The testing procedure depends upon the

particular instrument that you are using. Always follow the procedure given in the instruction manual for your tester. However, a general idea of the way in which a capacitor analyzer is used can be obtained from the following paragraph.

In general, a capacitor analyzer consists of a main capacity dial, which indicates the capacitance of the capacitor being measured; a range switch, which selects various ranges of capacity for the analyzer; a switch to set up the analyzer to measure either capacity or leakage resistance; a power-factor adjustment for measuring the power factor of capacitors; and an indicating device to show when the capacity bridge is balanced. This indicating device is usually an electron-ray indicator tube. Some analyzers also include a meter for making measurements of insulation resistance and leakage current of electrolytic capacitors and for other measurements. Most capacitor analyzers may also be used to measure resistance. The resistance value is also read on the main capacity dial.

As an example of the procedure used in testing a capacitor on a typical commercial analyzer, let us consider the testing of a capacitor on the SPRAGUE TEL-OHMIKE

Model TO-4 Capacitor Resistor Analyzer.
The procedure is as follows:

1. Depress the proper range pushbutton (in the row at top) depending upon the approximate range of the capacitor to be measured. Also set the POWER FACTOR switch (below the POWER FACTOR knob) according to the capacitor being measured. These settings are given in the instruction manual for the instrument.

2. Set the BRIDGE SELECTOR switch to CAP. This sets up the instrument to measure capacity.

3. Turn the a-c line switch on and set the VOLTAGE RANGE switch to the 600-volt position.

4. Connect the capacitor to be tested to the binding posts. If the capacitor is an electrolytic capacitor, observe the polarity markings on the binding posts.

5. Rotate the capacitor capacity dial pointer slowly from left to right until the eye in the electron-ray tube opens. Adjust the pointer carefully for maximum eye opening. Read the capacity underneath the pointer on the proper scale. Capacitors that can be balanced only at the extreme clockwise end of the dial on all ranges are open. Capacitors that can be balanced only at the extreme counterclockwise end of the dial scale are shorted. Intermittent capacitors will cause a flickering of the eye.

Capacitor Tolerances. The capacitance of paper capacitors that are color-coded should be within the tolerance specified by the color code. The capacitance of capacitors that are not color-coded are usually within $\pm 20\%$ of their rated value, except capacitors below $0.002 \mu\text{f}$, for which tolerances are larger. Mica capacitors are usually within $\pm 20\%$ of their rated value, unless the color-coding on them indicates closer tolerances.

The capacitance tolerance on coupling capacitors are usually more critical than those on bypass capacitors. Usually, $\pm 20\%$ units are satisfactory for most applications. However, in certain critical circuits, closer tolerances may be required. It is best to check the

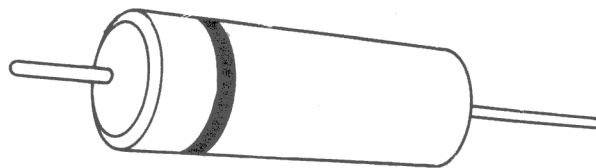


Fig. 15-13

manufacturer's specifications when in doubt.

Replacing Paper, Mica, Silver Mica, Ceramic, and Oil-Filled Types. When any of these capacitors is replaced, the new capacitor should have the same capacitance as the defective one being removed. The voltage rating should be the same as the old one, or higher, but never lower. It is best to use the same type that was removed until you get enough experience to choose other types. Paper capacitors usually are used only at audio frequencies in audio-amplifier and tone-control circuits. Mica and ceramic capacitors are usually used at i-f, r-f, and video frequencies. Mica and *tubular* ceramics may be used in critical circuits and in tuned circuits. Disc-type ceramics usually are used for applications such as bypassing. As pointed out in a previous section, tolerance of $\pm 20\%$ may be used in most circuits, unless a capacitor of closer tolerance is called for in the manufacturer's service data.

When installing a new capacitor in a radio chassis, try to place it in the same position that the old capacitor was in. When installing tubular bypass capacitors, be sure to connect the capacitor leads correctly. One end of the capacitor is marked GROUND or OUTSIDE FOIL or has a black stripe around the end, as shown in Fig. 15-13. The lead coming out of that end should be connected to the same point as the outside foil of the removed capacitor. The outside foil is usually connected to the point having the lowest potential. When one side of the capacitor is connected to ground, the outside foil side is always used as the ground side.

15-4. TESTING VARIABLE CAPACITORS

Two types of variable capacitors are most often used in receivers. These are the air-spaced ganged tuning capacitor and the mica

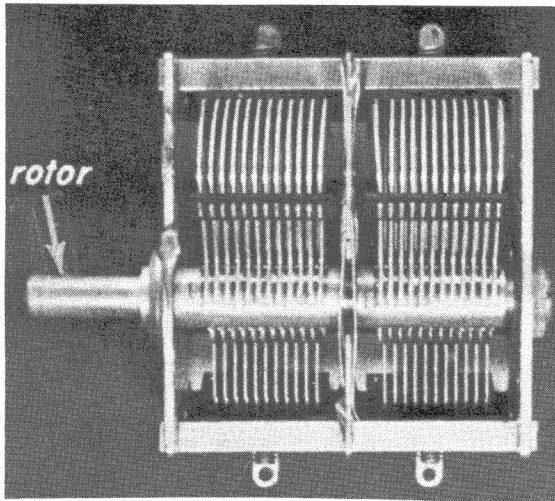


Fig. 15-14

trimmer capacitor. A typical tuning capacitor is shown in Fig. 15-14. The ganged tuning capacitor shown has two sections and consists of two separate capacitors, both of which have their capacitance values changed together when the rotor shaft is turned. The rotor shaft usually is electrically connected to the capacitor frame, and through it to the chassis ground of the receiver. Both sets of rotor plates are electrically connected to the rotor shaft. The rotor shaft connects both sets of rotor plates to a common ground point. The rotor plates turn within the air spaces separating the stator plates. There are two stator-plate sections; these sections do not connect to a common point as the rotors do, but instead go to separate terminals, which are insulated both from each other and from the rotor plates. Each of the two sections is connected to its own tuning coil; different stations are tuned in, and the rotors are adjusted to give the correct capacitance value by turning the tuning knob.

A mica trimmer capacitor is used to adjust each tuning section to the correct capacitance value. As a rule, these trimmers are built into the variable-capacitor unit. However, if the trimmers are not built in, mica capacitors such as those shown in Fig. 15-15 may be connected in parallel with each of the tuning sections, as shown in Fig. 15-16.

The trimmer capacitance is varied by means of the screwdriver adjustment. This adjustment causes the small metal plates

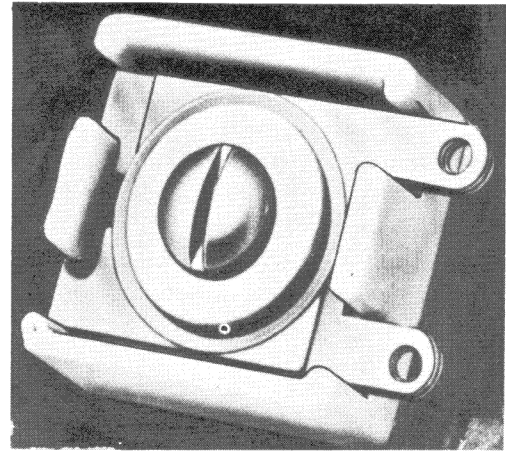


Fig. 15-15

within the trimmer capacitor to change their distance from each other. Small mica washers or sheets between the plates serve as the dielectric and prevent the plates from touching each other and shorting.

The most common faults found with ganged tuning capacitors are shorted plates, metal dust or particles between plates; and shorted trimmer capacitors.

Shorted plates are due to the rotor or stator plates being bent out of shape. When the rotors and stators touch, they short out the tuning coil. The receiver does not operate when the capacitor plates short out.

Sometimes a small metal particle falls between the rotor and stator plates and causes them to short at that point. This affects the operation of the set in the same manner as bent or touching plates.

Operation Test. The operation test consists of turning on the receiver and then tuning in each station, starting from the high-frequency end of the dial (1600 kc) and tuning towards the low-frequency end (550 kc). If all stations are received, the tuning

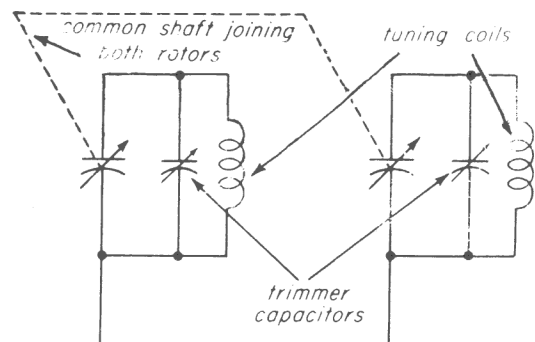


Fig. 15-16

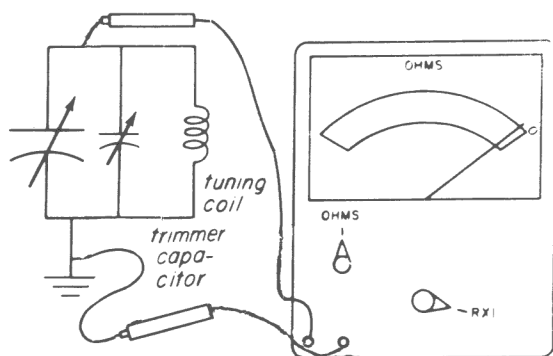


Fig. 15-17

capacitors are not shorted at any points. But if stations cannot be tuned in from 940 kc to 550 kc, it is possible that one of the tuning-capacitor sections is shorted when 940 kc is reached. A loud click is usually heard in the loud speaker when the meshing plates reach the shorting point.

Inspection Test. The inspection test consists, simply, of looking at the rotor and stator plates of both sections and making sure that their plates do not touch. The tuning knob is slowly turned and the plates are carefully inspected under a strong light. Look for metal particles or other foreign matter that may have fallen between the plates.

Ohmmeter Test. To test a tuning capacitor with an ohmmeter for shorts between the plates that have been caused by touching plates or metal particles between the plates, proceed as follows:

1. Shut off the set and remove the line plug from the power outlet. (If the set is a battery portable, remove all the tubes and disconnect the batteries).

2. Turn the ohmmeter-selector knob to the R x 1 position.

3. Turn the tuning knob of receiver until all the capacitor plates are out of mesh. Connect one test prod of the ohmmeter to chassis ground and the other prod to the stator terminal lug of one of the two sections, as shown in Fig. 15-17.

4. Observe the ohmmeter reading. If everything is normal, the reading should be in-

finiteness; if there is a tuning coil across the capacitor, the meter should indicate the d-c resistance of the tuning coil. This may be as low as one ohm. But if the ohmmeter reads zero ohms, the mica trimmer capacitor connected in parallel with that section may be shorted. This will be discussed later in this booklet.

5. If everything is normal, slowly turn the tuning knob so that the rotor plates start to mesh with the stator plates. Observe the ohmmeter indicating needle as the knob is turned and the plates go deeper into mesh. If the plates suddenly short, the needle will drop to zero ohms.

6. Repeat the same steps with the ohmmeter connected to the other tuning-capacitor section.

A more sensitive test may be made by testing each section with the ohmmeter selector knob in the R x 10 K position. When this is done, each tuning coil must be unsoldered from the stator lugs. The same steps are followed except that, in this case, the ohmmeter needle will not read the d-c resistance of the tuning coil but will remain at the left-hand end of the scale (infinite ohms) unless a shorting condition shows up. In that case, of course, the needle will indicate zero ohms.

Repairing a Shorted Variable Tuning Capacitor. If the operation, inspection, or ohmmeter tests indicates that a variable capacitor is shorted, proceed as follows:

1. Turn the tuning knob so that the plates are completely out of mesh.

2. Blow out all particles between plates, using a hand-operated tire pump or rubber ear syringe. A blown-up toy balloon may also be used.

3. Insert a pipe cleaner between the plates and clean out any remaining particles.

Caution: In order to avoid bending the plates, do not force the pipe cleaner between the plates of tuning capacitors having very narrow spacing. Use only air pressure to clean out the plates.

4. Check for shorts again, using the ohmmeter. If shorts are still present, proceed with step 5.

5. Carefully examine the capacitor plates under a strong light. Locate the bent plate at the position where it shorts. Carefully bend or press the plate back into a position in which it does not short against the next plate when going into mesh.

Repairing a Shorted Trimmer Capacitor. If an ohmmeter test shows a shorted condition when the rotor plates are fully out of mesh, the trouble probably is in the trimmer capacitor. This trouble usually is due to a defect in the thin mica separators or washers between the trimmer plates. Sometimes the mica either breaks or is missing entirely. If a trimmer is defective, replace it with a new trimmer capacitor, having the same capacitance.

Replacing Variable Tuning Capacitors. If a tuning capacitor is so badly damaged that it is impossible to repair it, it must be replaced. The new capacitor must have the same capacitance, number of plates, mounting holes, physical size, and direction of rotation as the original tuning capacitor. The plates of the replacement capacitor must have the same shape as the plates of the old one. This means that it is always best to order a new tuning capacitor directly from the manufacture of the radio receiver.

15-5. TESTING ELECTROLYTIC CAPACITORS

Electrolytic capacitors are used in radio receivers whenever values of capacity greater than about $1 \mu\text{f}$ are needed. They range in value from about $1 \mu\text{f}$ to a few thousand μf , with operating voltages from several volts to about 600 volts. They are available in many different shapes and forms, such as tubular shaped paper cartons with pigtail leads, as shown in Fig. 15-18a, paper-covered aluminum cans that are supported with mounting straps, as shown in Fig. 15-18b, or aluminum cans with threaded neck or twist prong mountings, as shown in Fig. 15-18c.

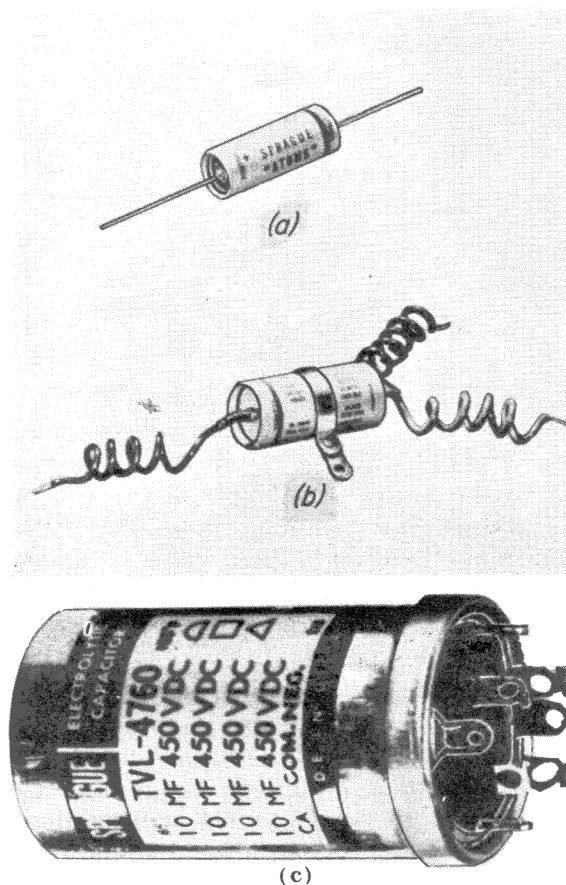


Fig. 15-18

Many electrolytic capacitors contain two or more separate capacitors in one unit. Color-coding of the leads or special markings on the can near the terminal lugs are used to identify the various sections. For example, the two-section capacitor shown in Fig. 15-19 has two red leads and one black lead. The marking on the case of the capacitor shows that black is the common lead; the red leads are the terminals of the two capacitors. Since the two capacitor sections are identical, there is no need to distinguish between the two red leads. However, if the two capacitor sections differed in either voltage rating or capacity, or both, three different colors would be used, as shown in Fig. 15-20.

In the case of twist-prong electrolytic capacitors, the can serves as the common lead for all the capacitor sections it contains. The individual capacitors are identified by a legend on the label, as shown in Fig. 15-21a. Corresponding symbols appear next to each terminal lug on the bottom of the can, as shown in Fig. 15-21b. The half-moon

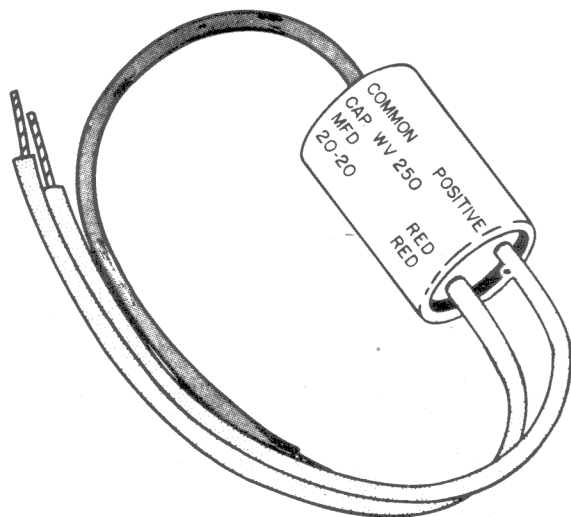


Fig. 15-19

symbol identifies the 80- μ f section; the rectangle symbol identifies the 40- μ f section; and the triangle symbol identifies the 100- μ f section. The 25- μ f section is identified by the fact that it has no symbol. Thus, lug 1 is the terminal of the 80- μ f 450-volt section; lug 2 is the terminal of the 40- μ f 350-volt section; lug 3 is the terminal of the 100- μ f 25-volt section; and lug 4 is the terminal of the 25- μ f 25-volt section.

The following methods can be used to test electrolytic capacitors:

1. Inspection method
2. Ohmmeter test

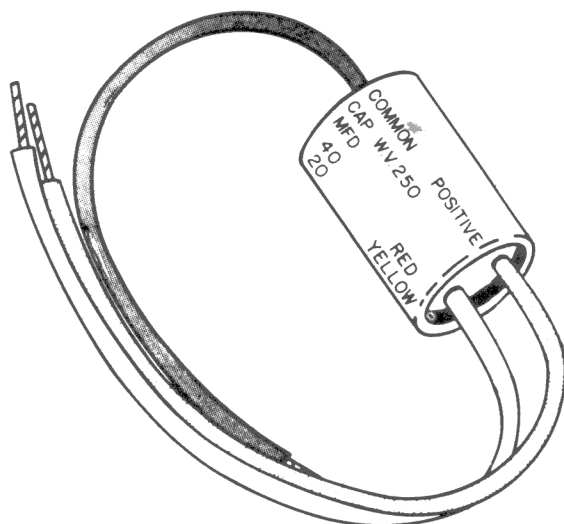
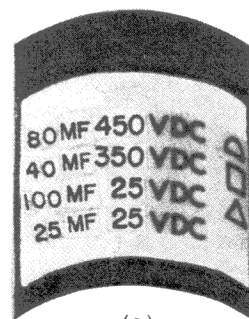


Fig. 15-20

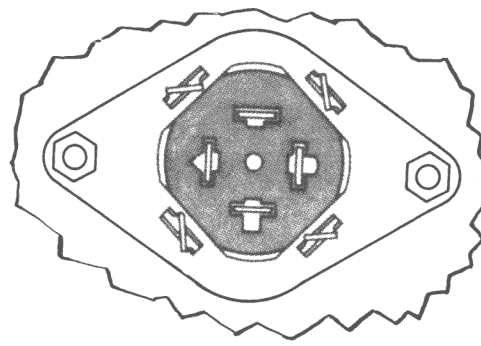
3. D-C voltmeter test
4. Substitution method
5. Capacitor-bridge test

Inspection Test. The inspection test consists of making a careful examination of the capacitor. First look for loose solder connections at the terminal lugs. If the metal can is the common terminal for all the capacitors within the can, make sure that the can makes good electrical contact with the chassis. Some metal-can capacitors are not supposed to make contact with the chassis. Such capacitors are mounted with an insulating washer that is placed between the can and the chassis to make sure electrical contact is not made. In this case, examine the small space between the can and the chassis to be sure that they do not touch and that metal particles do not short them together.

Also examine the capacitor for leaked-out electrolytic solution; if the metal can leaks, the capacitor should be replaced. The capacitor should be felt for excess heat after the radio has been operating a while. Electrolytic capacitors normally feel warm to the



(a)



(b)

Fig. 15-21

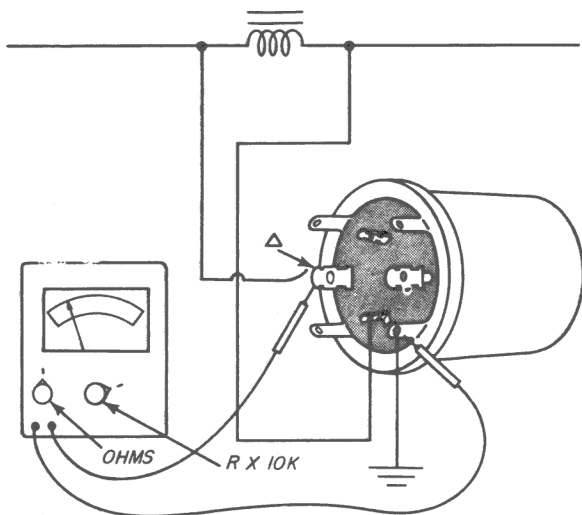


Fig. 15-22

touch after operating a while. A defective electrolytic capacitor sometimes, but not always, becomes hot to the touch. Experience in troubleshooting will soon tell you when a capacitor is normally warm or when it is too hot. A capacitor that overheats should be replaced with a new one unless *some other trouble* is causing it to get too hot. In that case, the other trouble must be corrected first.

Using the Ohmmeter. The ohmmeter may be used to test for shorted or leaky electrolytic capacitors. To test an electrolytic capacitor for a short, turn off the set and remove the line plug from the power outlet. If the set is a portable, remove all tubes and disconnect the batteries. Disconnect all leads. Set the ohmmeter selector knob to the $R \times 10 K$ position. Connect the positive probe to the positive terminal lug of the capacitor and the negative probe to the negative terminal, as shown in Fig. 15-22. In some commercial multimeters, the internal ohmmeter battery is connected so that positive voltage is present at the negative meter jack. This can be checked by examining the meter diagram. If this is the case, the positive meter test probe should be connected to the negative terminal of the electrolytic capacitor. In the case of metal-can electrolytics, the negative terminal is the metal can of the capacitor. Observe the ohmmeter needle. The needle should move rather quickly from left to right and then slowly back toward the left-hand end of the scale. After the needle has come to a complete rest, read the scale. This is

the leakage resistance of the capacitor, and its value will depend upon capacitance, age, amount of recent use, and other things. So it is difficult to say what the exact leakage of an electrolytic capacitor should be. The leakage resistance of an electrolytic capacitor need not be as high as that of paper. High-voltage electrolytics (from about 100 to 450 volts) should have a leakage resistance of more than 0.5 megohm, while low-voltage electrolytics should not go below 0.1 megohm. As an additional test, feel how hot the capacitor gets after the set has operated for a while. Then measure the leakage of the capacitor and also use the operating test to see if the amount of leakage measured is causing trouble. All three indications tell whether the capacitor should be replaced or not. The capacitor analyzer may also be used to test the leakage of electrolytic capacitors. You will learn about this a little later in this booklet.

Voltmeter Test. The d-c voltmeter can be used to help find a shorted electrolytic capacitor. For example, Fig. 15-23 shows that C_4 is used as a power-supply filter capacitor. When you learn more about power supplies and troubleshooting, you will know that normally a large d-c voltage should be measured across C_4 . But if C_4 becomes shorted or leaky, this voltage will be reduced. To test the capacitor for shorts with the voltmeter, first disconnect the capacitor from the circuit. With the voltmeter, measure the voltage at the point where the capacitor was connected, as in the figure. Then reconnect the

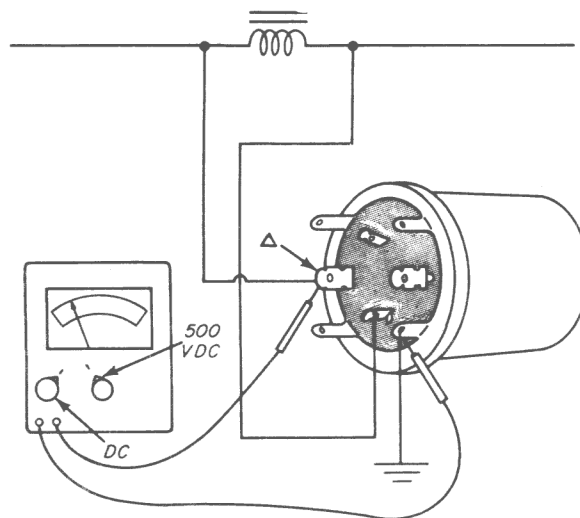


Fig. 15-23

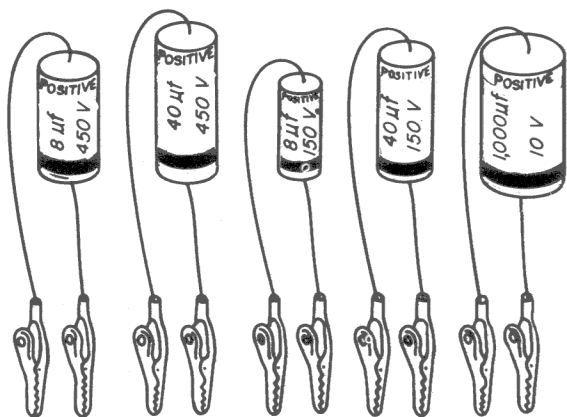


Fig. 15-24

capacitor while observing the voltage at this point. Reconnecting the capacitor should make the voltage rise slowly or remain the same. If the voltage decreases when the capacitor is connected, the capacitor is shorted or has excessive leakage. Correct polarity must be observed, with the positive probe of the voltmeter connected to the positive terminal of C_4 and the negative probe connected to the metal can. The selector knob of the voltmeter should be turned to the 500 VDC position.

Substitution Method. The substitution method is often used to quickly test for an open electrolytic capacitor or one that has changed its capacitance value. Figure 15-24 shows several capacitors with clips attached. Each capacitor has a different capacitance rating. Use high-voltage ratings for your test capacitors. When using this method, the capacitor used for substitution should be the one that is closest in capacitance value to the one that is to be tested. For example, suppose that we want to test capacitor C of Fig. 15-25 to determine if it open. (We think it may be a possible cause of hum in a defective receiver.) Select a correct substitution capacitor and connect the clips so that both capacitor C and the substitution capacitor are in parallel, as shown in figure. The positive terminals of both capacitors must be connected together. If the hum disappears, capacitor C is open and must be replaced. The same method will also tell if capacitor C has lost capacitance value; this also causes hum. If a substitution capacitor is placed in parallel with capacitor C and the hum disappears, capacitor C should be replaced.

When capacitors are tested by the substitution method, the suspected capacitor must first be disconnected from the circuit. Then the substitution capacitor can be put in its place. Capacitors that are open or that have changed value do not always cause hum to be heard but often cause other symptoms and defects to occur in radio receivers. After you have become more expert in troubleshooting, you will learn how to apply the substitution method to cure these other defects.

Capacitor Analyzer Test. The capacitor analyzer shown in Fig. 15-12 can be used in order to quickly and easily test any electrolytic capacitor for capacitance value, leakage resistance, and shorts. The capacitor should be disconnected from the radio receiver and connected to the test terminals. After making the correct settings, according to the instructions given with the instrument, the capacitance value may be read on the dial scale. If the capacitance is less than 75% of the normal value, the capacitor should be replaced with a new one. For example, if an electrolytic capacitor is normally $20\ \mu\text{f}$, 75% of that is $15\ \mu\text{f}$. If it measures less than $15\ \mu\text{f}$ on the capacitor-analyzer bridge, it has lost too much capacitance.

Current Leakage in Electrolytic Capacitors.

The leakage resistance of an electrolytic capacitor is also measured by seeing how much d-c current flows through it. The greater the current flow, the worse the leakage. Instructions that come with the capacitor

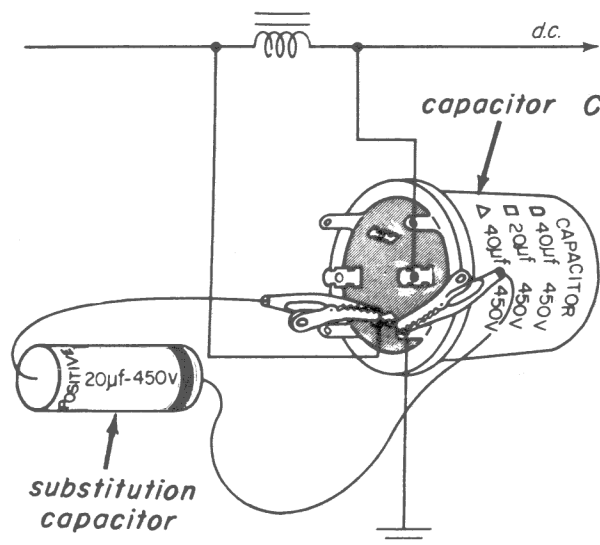


Fig. 15-25

analyzer show how much current should normally flow for different electrolytic capacitors.

Replacing Electrolytic Capacitors. When electrolytic capacitors are replaced, the new capacitor should have the same capacitance value and voltage rating as the one being replaced. The original defective capacitor is removed from the circuit and the new one is installed in its place. Be sure that you have the correct polarities. A metal-can capacitor may be used to replace a defective tubular capacitor, and a tubular type can replace the metal-can type. However, when the metal-can type is used to replace the tubular type, a location on the chassis must be found where a new hole can be drilled to mount the metal can. It is best, in most cases, to replace the tubular type with another tubular capacitor in order to avoid having to drill the hole.

If only one section of a multisection electrolytic capacitor becomes defective, it is usually advisable to replace the entire unit. However, if an exact multisection replacement is not available, a repair may be made by disconnecting the defective capacitor section from the circuit. A new electrolytic capacitor should be installed in place of the defective section. The new capacitor should, of course, have the same capacitance value and voltage rating as the defective section. Correct polarities must be observed.

Be careful when you are making connections to the negative terminal of the multisection capacitor unit. In many cases, the negative lead or terminal connects to the radio chassis, but often it does *not*. Figure 15-26 shows how a new tubular electrolytic capacitor replaces the defective section of a

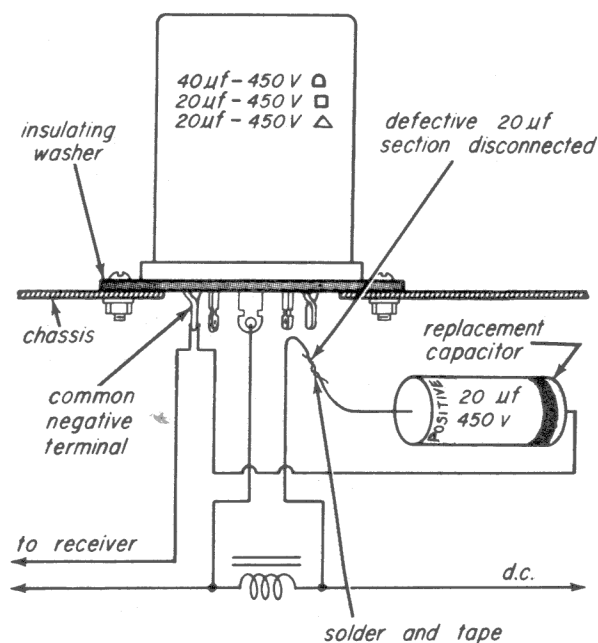


Fig. 15-26

multisection capacitor having a common negative terminal that does not go to chassis ground. In other words, the metal can or container that acts as the negative terminal does not touch the chassis. A fibre insulating washer installed by the radio manufacturer between the metal can and the radio chassis prevents electrical contact from being made. Therefore, the negative terminal of the new replacement capacitor does not go to chassis ground, but connects to the ungrounded lug of the metal can. If the entire can is to be replaced, be sure to use an insulated mounting washer if the original can was mounted with one.

If the aluminum can of the multisection capacitor is connected to the chassis, the negative terminal of the replacement capacitor is connected to a chassis ground. The defective section should be disconnected and a new capacitor having the same voltage rating and capacitance value should be connected to the terminals. Be sure that you have the correct polarities.